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(54) **Method and apparatus for controlling the dissemination of digital information**

Verfahren und Vorrichtung zur Kontrolle der Verbreitung von digitaler Information

Procédé et dispositif pour contrôler la dissémination d'information numérique

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- **SYSTEMS & COMPUTERS IN JAPAN, vol. 19, no. 5, 1 May 1988, pages 50-60, XP000110614 SHUICHI TASHIRO ET AL: "IMPLEMENTATION OF A SMALL-SCALE PROTOTYPE FOR SOFTWARE SERVICE SYSTEM (SSS)"**
- **THE TRANSACTIONS OF THE IEICE, vol. E73, no. 7, July 1990, TOKYO, pages 1133-1146, XP000169229 MORI ET AL: "Superdistribution: The Concept and the Architecture"**
- **PROCEEDINGS OF THE NETWORK OPERATIONS AND MANAGEMENT SYMPOSIUM, KISSIMMEE, FEB. 14 - 17, 1994, vol. 2 OF 3, 14 February 1994, INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, pages 486-496, XP000452345 ROZENBLIT M: "SECURE SOFTWARE DISTRIBUTION"**

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## Description

### Background of the Invention

#### 1. Field of the Invention

The present invention relates to the field of data processing, and in particular, to a method and apparatus for controlling the dissemination of digital information. Furthermore, the present invention provides transparent access to uncontrolled digital information together with controlled digital information with the same access apparatus.

#### 2. Description of the Related Art

The distribution of original works - whether be it text, graphics, animation, video or audio - in magnetic, electronic, optical or any other medium is becoming popular. Advances in digital compression technology and improvement in the price/performance ratio of computers have made it economical and feasible to disseminate digital information in such "soft" forms. However, original works encoded in digital medium can be easily duplicated, encrypted, transmitted via communication networks and destroyed. For the remainder of the description of the present invention, original works encoded in digital medium shall be referred to as digital information. The push factors, i.e., easy access and manipulation, that make digital information a rival to the traditional hard copy forms, i.e., books, newspapers or microfiches, have also made it difficult to establish evidence of illegal usage of such information.

With respect to the distribution of hard copies of original works, copyright and publishing laws strike a balance between the twin goals of compensating the publisher/author and of maintaining reasonable cost to the end users. It is straightforward to establish evidence of making illegal copies of hard copy of original works. The main thrust of copyright and publishing laws is to establish evidence of illegal possession.

In contrast, evidence of illegal possession of digital information is difficult at best and at worst impossible to obtain. The present invention proposes to control the usage of distributed digital information as an alternative. By usage, the present invention refers to the number and timing of the accesses specified by the information provider.

Prior art controls the dissemination of software programs only with copy protection schemes. Copy protection relies on hardware or software artifacts to detect and prevent illegal copying of software programs. Encryption is sometimes used to provide copy protection. Some recent examples of copy protection schemes are U.S. patent No. 4,866,769 to Karp and U.S. patent No. 4,903,296 to Chandra et al.

U.S. Patent No. 4,903,296 claims copy protection of software on magnetic medium with a special key hav-

ing two marks made on the surface of the medium. These marks are in the form of absence of material and domains that cannot be formed by conventional magnetic disk write heads. Additionally, an encrypted key which is critical for running the application is built into a special purpose hardware subsystem. Finally the hardware subsystem is required to decrypt the key.

U.S. Patent No. 4,866,769 teaches a method of copy protection of personal computer software distributed in diskettes through the use of a unique identification stored in read only memory of a personal computer. A source ID is provided with every software distributed. The personal computer ID is used with the source ID on the distribution diskette to produce an encoded check word, using any available encryption method. This check word is then used to verify that the software is being used on the designated personal computer.

While U.S. Patent Nos. 4,903,296 and 4,866,769 disclose off-line schemes for controlled dissemination of software, U.S. Patent No. 4,999,806 describes a central station distributing software over telephone lines - an on-line scheme for software dissemination. The central station transmits an acceptance code to a caller and then terminates the call. After verifying the caller's credit information, the central station calls the purchaser back and continues with the transaction only after receiving the acceptance code. The central station then transmits a Control Transfer Program and Initialization Program to the purchaser. The purchaser executes the Initialization Program to turn over control of the purchaser's computer to the central station. The Control Transfer Program makes sure that no memory resident copying programs are running before transmitting over the telephone line the purchased/leased program to the purchaser's computer. Thereafter the various transmitted programs are erased, leaving only a copy of protected version of the purchased program on the purchaser's disk.

To prevent unauthorized copying and use of information, prior art copy protection schemes require either introducing artificial indicia as software keys or requiring special hardware subsystems. Not only are these solutions costly to both the information providers and the end users as they require additional processing steps, but they are also incompatible with the trend of encouraging concurrent use of different types of information in a network environment. Furthermore, the prior art copy protection schemes provide limited control over the dissemination of digital information in that they prevent unauthorized copying of software but not "uses" of such information.

Absent from the prior art is the dissemination of uncontrolled information. By uncontrolled information, the present invention refers to a portion of the information which the information provider has decided to let the end user view without registering it as a "use" of the controlled information. Typically, the uncontrolled information is either at a lower resolution compared with the control-

led information or it comprises a selected portion of the controlled information which allows the end user to make an informed decision whether to subscribe or use the controlled information. Examples of uncontrolled information are the preview of a movie, or a demonstration version of the controlled software, or even an abstract of a patent document. Hitherto, prior art information dissemination system does not permit the transparent access of uncontrolled digital information with the same access device as that for accessing the controlled digital information.

In the articles "The concept of a Software Service System (SSS)" and "Implementation of a Small-Scale Prototype for Software Service System (SSS)" by Mori and Tashiro, Systems and Computers in Japan, Vol. 19, No.5 1988, pages 38-60, a software licensing system is described in which software access rights are encrypted in a header which is distributed with the software. In this SSS system, any modification of access rights (decrementing a number-of-accesses counter, for example) is performed using a special tamper-proof "SSS-Box".

#### Summary of the Invention

The present invention relates to a method for controlling the dissemination of digital information as set out in claim 1, and claim 4.

#### Brief Description of the Drawings

FIG. 1 is a model of information dissemination.

FIG. 2 illustrates a logical structure of a Sealed Controlled Information (COIN) according to a first embodiment of the present invention.

FIG. 3 shows the architecture of a device used by an information consumer for accessing the controlled information according to the first embodiment of the present invention.

FIG. 4 illustrates the logical flow of how the Sealed COIN is prepared by an information provider.

FIGS. 5A & 5B show the logical flow of the controller in the access device according to the first embodiment of the present invention.

FIG. 6 illustrates the architecture of an access device for a system for controlled dissemination of digital information according to the second embodiment of the present invention.

FIG. 7A illustrates a possible format of the logical structure of Sealed COIN used in a second embodiment of the present invention.

FIG. 7B illustrates a possible format of the logical structure of the Sealed Opener which cooperates with the Sealed COIN used in the second embodiment of the present invention.

FIG. 8 illustrates the flow diagram of the information provider used in the second embodiment of the present invention where a Sealed COIN is generated.

FIG. 9 shows the flow diagram of the information

provider used in the second embodiment of the present invention where an opener for accessing the sealed COIN in FIG. 8 is generated.

FIG. 10 illustrates the logical flow of the overall process of on-line controlled dissemination of information according to the second embodiment of the present invention.

FIGS. 11A and B illustrate the flow diagram of the controller in the access device according to the second embodiment of the present invention.

#### Detailed Description of the Invention

A method and apparatus for controlling the dissemination of digital information is described. In the following description, numerous specific details are set forth such as logical structures of digital information and program steps, etc. In order to provide a thorough understanding of the present invention. It will be obvious to one skilled in the art that the present invention may be practiced without these specific details. In other instances, well-known steps such as those involved with encryption and decryption of data are not shown in order not to obscure the present invention.

#### Notation and Nomenclature

The detailed description with respect to the controlled dissemination of digital information is presented partially in terms of algorithm and symbolic representation upon operation on data bits within a computer memory. These algorithmic descriptions and representations are the means used by those skilled in the data processing art to convey most effectively the substance of their work to others skilled in the art.

An algorithm is here, and generally, conceived to be a self-consistent sequence of steps leading to a desired result. These steps require physical manipulation of physical quantities. Usually, though not necessarily, these quantities take the form of electrical, optical or magnetic signals capable of being stored, transferred, combined, and otherwise manipulated. It proves convenient at times, principally for reason of common usage, to refer to these signals as bits, values, elements, symbols, characters, numbers or the like. It should be borne in mind, however, that all of these and similar terms are to be associated with the appropriate physical quantities and are merely convenient labels applied to these quantities.

Further, the manipulations performed are often referred to in terms such as adding or comparing, which are commonly associated with the mental operations performed by a human operator. No such capability of a human operator is necessary, or desirable. In most cases, in any of the operations described herein which form part of the present invention, the operations are machine operations. Useful machines for performing the operations of the present invention include general

purpose digital computers or similar devices. In all cases, it should be borne in mind that there is a distinction between the method operation in operating a computer or other apparatus and the method of computation itself. The present invention relates to method steps for providing better control over the dissemination of digital information.

The present invention also relates to an apparatus for performing these operations. This apparatus may be specially constructed for the required purpose or it may comprise a general purpose computer as selectively activated or reconfigured by a computer program stored in the computer. The algorithms presented herein are not inherently related to any particular computer or other apparatus. In particular, various general purpose machines may be used with programs written in accordance with the teachings herein, or it may prove more convenient to construct specialized apparatus such as a dedicated processor to perform the required method steps. The required structure for a variety of these machines would appear from the description given below.

#### GENERAL SYSTEM CONFIGURATION

A general model of information dissemination is shown in FIG. 1. Here, the Information Provider 10 refers to a supplier of all types of information including but not restricted in form to text, graphics, animation, video, audio, software, or any combination thereof. The transmission channel 20 represents the means and more specifically the media through which information is delivered to the Information Consumer 30 over paths 15 and 25. The transmission channel 20 includes but is not limited to any communication means or media such as computer networks, satellite links, diskettes, optical disks or other storage medium. It should also be understood by one skilled in the art that Information Consumer 30 is used interchangeably with one or more end users of information. The present invention chooses the word "information consumer" to highlight the use-once nature of the controlled information. In other words, once controlled information is consumed, the original information no longer exists in a usable form and the re-access to the same information is not automatic. The use-once nature can be generalized to use-n-time, i.e., once the controlled information has been used for n times, it no longer exists in a usable form.

This invention teaches methods and apparatus for an information provider to prepare information packaging for dissemination. These methods are going to be described in specific steps of manipulating information. For one skilled in the art, it is obvious that some of these steps shall be best automated by, for example, implementing them as a special purpose software, which is normally called a server, running on general purpose computers. It is also clear that an information provider could simultaneously instantiate multiple executions of the server to serve multiple information consumers. For

clarity of presentation, the description below shall elaborate on the model having one provider and one consumer in our description. It is also clear that an information consumer may also be another information provider.

#### FIRST EMBODIMENT OF THE PRESENT INVENTION

##### 1. Preparation of distribution package

FIG. 2 illustrates a logical structure of a Sealed Controlled Information (COIN) according to a first embodiment of the present invention. The Sealed COIN is prepared by an information provider once the information consumer agrees to the terms of an information distribution contract. The first embodiment of the present invention describes an off-line scheme where the transmission channel 20 comprises any kind of non-volatile storage medium such as a floppy disk, a hard disk, an optical disk and other non-volatile semiconductor storage devices. An information distribution contract contains at a minimum the identity of controlled information, the number of accesses, and the type of transmission medium 20.

Referring again to FIG. 2, the logical structure of the Sealed Controlled Information (COIN) comprises a header 35 and a body 40. COIN refers to the original information encoded in some "soft" form (e.g., electronic, magnetic or optical) that the Information Provider 10 shall provide to the Information Consumer 30 for his access for a predetermined number of times. COIN is encoded or sealed by using some scheme such that accessing the COIN without a valid decryption key is computationally intractable. The header 35 further comprises a plurality of fields: a medium signature 36, an access window 37 (AW), total number of legal accesses allowed 38 (TAL), the number of legal accesses left 39 (LAL), and TAL number of encryption/decryption keys 41 ( $K_1$  to  $K_{TAL}$ ). The medium signature 36 refers to any scheme which allows a distribution medium, such as a floppy disk, to have a unique identification. Preferably, this signature depends upon the characteristics or nonuniformities of the distribution medium. For an example of a suitable medium signature, please refer to the pending U. S. application serial No. 08/120,969, filed 13 September 1993, by the same assignee as the present invention. The AW 37 refers to a specified time period within which a legal access is granted to the information consumer for accessing the COIN. A start and end time is given as the boundary of the access window in which the Information Consumer 30 can access the disseminated information legally. TAL 38 is the total number of legal accesses to the COIN granted by the Information Provider 10 to the Information Consumer 30 under an information dissemination contract. LAL 39 is the number of legal accesses left; it is the difference between TAL and the number of accesses already granted. When LAL is equal to zero, access to COIN shall be denied.  $K_1$  to

$K_{TAL}$  41 are keys used for decrypting the COIN in the body 40. Preferably the encryption and decryption scheme of  $K_1$  to  $K_{TAL}$  41 is based on Public Key Cryptography (PKC) which allows the information provider to transmit secret messages to the access device without prior transmission of a secret key. Under PKC, each party has a pair of keys - one secret (known only to itself) and one public (known to everyone like a telephone number in a telephone directory). In other words, the information provider has a secret key (SSK) and a public key (SPK) while the access device has a secret key (DSK) and a public key (DPK). When the information provider sends a secret message to the information consumer, the information provider uses the access device's public key (DPK) to encrypt the message. Only the access device can decrypt the encrypted message by using its own secret key (DSK). For further reference on PKC, see R.L. Rivest, A. Shamir and L. Adleman: "A Method for Obtaining Digital Signature in Public-Key Cryptosystems" Communications of the ACM, Vol. 21, No. 2, February 1978, pp. 120 - 126. Also see D.E.R. Denning, *Cryptography and Data Security*, Addison-Wesley, Reading, MA, 1983.

Once the Information Consumer 30 agrees with the Information Provider 10 on the terms of the distribution contract, Information Provider 10 executes a procedure as outlined in FIG. 4 beginning with step 60 to produce a distribution medium incorporating the sealed COIN. In step 62 TAL number of keys,  $K_1$  to  $K_{TAL}$ , are generated for encrypting COIN in the body 40. Although PKC is referred in the embodiment of the present invention, any method of encryption is applicable. Next, a medium signature 36 is created from the particular distribution medium on which COIN is to be distributed. Pending U.S. application serial No. 08/120,969, filed 13 September, 1993, and assigned to the same assignee as the present invention exemplifies one of many ways of generating a medium signature. In step 66, COIN is encrypted with  $K_1$ . It follows that the body 40 of the sealed COIN is generated. In step 68, the header 35 is prepared next. Initially the value LAL 39 is set to be identical with that of TAL 38. By concatenating AW 37, TAL 38, LAL 39,  $K_1$  to  $K_{TAL}$  41, and medium signature 36 as illustrated in FIG. 2, the header 35 is then encrypted in step 68 using the public key DPK of the information consumer's access device. The encrypted header 35 and the encrypted body 40 constitutes the sealed COIN and is written onto the distributed medium in step 70.

## 2. Access of information

It is assumed that the Information Consumer 30 has some device, for example a computer, to access the information in the distributed medium. The minimum enhancements to such a device for accessing COIN are shown in FIG. 3. A Controller 45 is coupled at its input to an information input channel 27 for receiving disseminated information from the read device (not shown) of

distributed medium. The Controller 45 is also coupled at one of its outputs to an information output channel 29 for transmitting re-encrypted information to the write device (not shown) of the distributed medium. The function of Controller 45 shall be described below in the description of FIG. 5. It should be understood by one skilled in the art that the Controller 45 can be implemented fully in hardware or by a general purpose processor with the appropriate software. The controller 45 is also coupled at the other output to an output unit 50 over a link 47 for displaying the disseminated information. The output unit 50 could be a display unit for text/graphics/animation/video or a transducer for audio information. The output unit 50 could itself be a device for distributing controlled information to other information consumers. The controller 45 is also coupled to a clock 55 over link 49 for counter-checking whether the real time is within the boundary of the access window AW 37. Preferably, the clock 55 and the access device are tamper-proof such that the information consumer may not tap into the link 47 nor alter the value of the clock 55. It should be understood by one skilled in the art that the controller has means to interact with the user, the details of which are omitted in order not to obscure the description of the first embodiment of the present invention.

FIGS. 5A & 5B summarizes the logical flow of the Controller 45 of the access device in accordance to the first preferred embodiment of the present invention. When the Information Consumer 30 wishes to access the sealed COIN, he or she loads in step 80 the medium read/write device with the distribution medium (not shown) containing the sealed COIN. The Controller 45 of the access device is presented with the information read from the medium read/write device via the input channel 27. The Controller 45 checks in step 82 whether the information at the input channel 27 is encrypted. If the information is unencrypted, i.e., uncontrolled information, the Controller 45 allows the information at the input channel 27 to pass directly in step 84 to the output unit 50 over the link 47. However, if the information at the input channel 27 is encrypted or controlled, the Controller 45 decrypts the header 35 of the sealed COIN by using in step 88 the secret key DSK of the access device. As mentioned above, the secret key DSK is unknown to the Information Consumer 30. Next in step 90, the Controller 45 checks whether there are any legal access left by testing the value of LAL 38 for zero. If there are no legal accesses left, the value of LAL 38 = 0 and an evade processing module is invoked in step 92 which either denies the information access or erases the contents of the medium. The specific action depends on a particular embodiment of the invention. Should the value of LAL be greater than zero, then the Controller 45 compares in step 94 the value of the access window AW 37 with the time of the clock 55. If the current time falls outside of the boundary of the AW 37, the evade processing module in step 92 is invoked. Otherwise, the Controller 45 checks in step 96 whether the medium sig-

nature 36 corresponds with the signature read from the input channel 27 and that of the output channel 29. If the medium signature 36 does not match, the sealed COIN is stored on a copied medium. An evade processing module as in step 92 is invoked. Otherwise, the Controller 45 confirms that the Information Consumer 30 has a right to access the sealed COIN on the distribution medium.

It should be obvious to those skilled in the art that the controller of the access device of the present invention permits the information consumer to access transparently uncontrolled and controlled information in an off-line manner by using the same access device. While the present invention obviates the task of switching back and forth between at least two access devices, it also allows the information provider to distribute uncontrolled and controlled information in one package. With greater information at the disposal of the information consumer, usage of controlled information under the terms of the information provider is encouraged.

After the Controller 45 determines that the Information Consumer 30 has a right to access the sealed COIN on the distribution medium in FIG. 5A, the controller extracts in step 95 the encryption/decryption key  $K_{\text{TAL}} - \text{LAL} + 1$  from the header 35. The Controller 45 disables dumping of decrypted information via the output channel 29. The Controller 45 then decrypts the sealed COIN by using the key  $K_{\text{TAL}} - \text{LAL} + 1$  in step 98. The decrypted information, COIN, is provided in step 100 in FIG. 5B as output to the output unit 50 over the link 47. It follows that the Information Consumer 30 accesses the COIN transparently while the Controller 45 checks, validates, encrypts and decrypts the appropriate controlled information automatically. In step 102 the Controller 45 decrements the value of the LAL by one. The header 35 thus become modified header 35'. Should the value of LAL equals zero as tested in step 104, then a "disable information access" module is invoked in step 106 which for example, erases the sealed COIN from the distribution medium. If the value of LAL is  $> 0$ , then the Controller 45 extracts the encryption/decryption key  $K_{\text{TAL}} - \text{LAL} + 2$  and encrypts the COIN in step 108. The Controller 45 then encrypts the modified header 35' by using the public key DPK of the access device. Finally the Controller 45 writes the new sealed COIN generated by this encrypted COIN 40 and the encryption of the modified header 35' onto the distribution medium via output channel 29 in step 110. Thus, the procedure described in FIGS 5A and 5B implements a "use-n-times" controlled information scheme that give the information provider enhanced control over the dissemination of digital information.

## SECOND EMBODIMENT OF THE PRESENT INVENTION

### 1. Overall system set-up and operations

The second embodiment of the present invention describes an on-line scheme for controlled dissemination of digital information. Referring once again to FIG. 1, the transmission channel 20 comprises a variety of communication links between the Information Provider 10 and the Information Consumer 30. For instance, the transmission channel 20 could include a computer network or even telephone lines.

The architecture of an access device modeling the Information Consumer 30 for an on-line scheme is illustrated in FIG. 6. Controlled information from the transmission channel 20 is presented to the Information Consumer 30 over an input channel 27 which is coupled to a Controller 48. The functions of the Controller 48 shall be elaborated in connection with the description of FIG. 11. The Controller 48 can be implemented either in hardware or by a general purpose processor with proper software. Referring again to FIG. 6, the Controller 48 is coupled to an output unit 50 over a clear channel 47. Just as in the first embodiment of the present invention, the output unit 50 comprises a device for outputting controlled information or a mechanism for distributing controlled information to others. The Controller 48 is also coupled to a memory storage 52 and a clock 55 for reasons which shall be explained below. The Controller 48 is coupled to an output channel 29 for outputting re-encrypted controlled information. Preferably, the various channels coupled to the Controller 48 are tamper-proof. This will make it impossible for users to tap into the clear channel 47, to access the Controller 48, to alter the value of the memory storage 52, or to change the value of the clock 55. It should be understood by one skilled in the art that the controller has means to interact with the user, the details of which are omitted in order not to obscure the description of the second embodiment of the present invention.

The objective of the on-line scheme of controlled dissemination of digital information is to achieve improved control of the delivery of information so that once the information is accessed by the Information consumer for a specified number of times, the information no longer exists in a usable form without authorization from the information provider. The enhanced control of information dissemination is achieved by using encryption and by limiting an information consumer's access at a designated legal access device during an access window.

In order to achieve the above mentioned controls, the encrypted COIN is packaged with some control data, which is called the "header" while the encrypted COIN is called the "body". The header and body together are called the Sealed-COIN. A user presents the Sealed-COIN together with a ticket to the access device in order

to access the COIN. This ticket is called "Seal Opener" or just "Opener" for short. The Openers are issued by the Information Provider at user's request. FIGS 7A and 7B illustrate possible logical structures of Sealed-COIN and Seal Opener for realizing the second embodiment of the present invention. Below are definitions of specific terms and acronyms needed in the rest of the description:

COIN	Original information encoded in some digital form; identified by unique identification, IID.
TAL	Total number of legal access to the COIN allowed by the Information provider to information consumer.
LAL	Number of legal access left.
LAD	The device on which the COIN can be accessed legally.
PID	Unique identification number of information provider.
UID	Unique identification number of information consumer.
CID	Unique identification of a contract of information dissemination. Logically, a contract associates PID, IID, TAL, LAD and UID.
AW	Access window is the time during which a legal access is granted to COIN.

An agreement or contract of information dissemination (CID) between an information provider and an information consumer provides at a minimum that the information provider shall provide some COIN to the information consumer for TAL number of legal accesses on certain LAD. As such, CID associates with PID, IID, TAL, LAD and UID respectively. In the simplest form, a CID is formed by concatenating PID, IID, TAL, LAD and UID as illustrated logically in FIG. 7A. It should be understood by one skilled in the art that although the fields 121 to 129 in FIG. 7A are drawn in some order, the structure of CID 120 in any implementation is not bound by this order and arrangement. Similarly, the generality of the preceding comments applies to FIG. 7B. CID 120 expires when all of TAL 125 number of accesses have been made.

Referring again to FIG. 7A, a Sealed-COIN comprises a header 119 and a body 130. As mentioned above briefly, body 30 is the original COIN which has been encoded by using some encryption scheme so that obtaining the COIN without a valid decryption key is computationally intractable. The decrypted header 119 further comprises three fields: CID 120, LAL 122 and keys 124. Keys 124 consist of TAL number of keys  $K_1$ ,

$K_2$ , ...,  $K_{TAL}$ . They are used to decrypt the body and further encrypt the COIN to form new Sealed-COIN.

FIG. 7B shows the logical structure of a Seal Opener. It too has a header 140 and a body 145. The header 140 has two fields: CID 131 and AW 142. CID 131 of the Opener is identical to the CID 120 of the Sealed-COIN. The AW 142 holds a number of access windows during which the information consumer may access the COIN. The body 145 contains a decryption key  $K_H$  for the header 119 of the Sealed-COIN in FIG. 7A. The key  $K_H$  is maintained for the life of contract CID. For the second embodiment of the present invention, a Public Key Cryptography scheme as well as a conventional secret key scheme are used to illustrate the on-line scheme of information dissemination. With respect to a Public Key scheme, the present invention denotes the secret and public keys of Information Provider 10 by PSK and PPK, respectively, and the secret and public keys of the access device by DSK and DPK, respectively.

FIG. 10 illustrates the logical flow of the overall process of on-line controlled dissemination of information of the present invention. The on-line scheme of the present invention commences with the establishment of a contract between an Information Provider 10 and an Information Consumer 30 in step 168 of FIG. 10. At this juncture, a CID and its associated fields PID 121, IID 123, TAL 125, LAD 127 and UID 129 are stipulated in the contract. Based on this information, the Information Provider 10 generates a Sealed-COIN as illustrated in FIG. 8, and transmits it over the transmission channel 20 to the information consumer in step 170 of FIG. 10. The information consumer then makes a request to the Information Provider 10 over the same channel in step 172 of FIG. 10. After verifying the information consumer's request in step 174 of FIG. 10, the Information Provider 10 generates an Opener as outlined in steps 160 - 166 of FIG. 9 and transmits the Opener to the information consumer in step 174 of FIG. 10. The information consumer presents the Sealed-COIN received earlier and the Opener to Controller 48 for accessing the COIN in step 176.

In determining whether to grant the information consumer's request for access in step 178, the Controller 48 applies the logical sequence of steps as outlined in FIGS. 11A and 11B details of which shall be elaborated below. Should an access be granted, the Controller 48 checks if the CID contract has expired in step 182 of FIG. 10, i.e., whether all the TAL number of accesses have been made by the information consumer. If not, the COIN is re-sealed as described below and the outcome is made available to the information consumer through the Information Output Channel 29. The information consumer saves the re-sealed COIN for future access in step 184. For subsequent accesses, the information consumer starts from step 172 by making another access request to the Information Provider 10. This continues until the expiration of the contract as in step 180.

## 2. Preparation of Sealed-COIN and Seal Opener

FIG. 8 describes how an information provider generates a Sealed-COIN. The Information provider is ready to generate a Sealed-COIN in step 150 if it has the CID and the values of the associated quantities, namely, PID, IID, TAL, LAD and UID. The Information provider first generates TAL number of keys,  $K_1, K_2, \dots, K_{TAL}$ . In step 152. Next, in step 154, the Information provider forms the header fields 119 of the Sealed-COIN by combining the CID for field 120, the value of TAL for field 122 and the keys for field 124. Then the body 130 of the Sealed-COIN is formed by encrypting the COIN identified by IID with key  $K_1$ . The header fields 119 in turn are encrypted in step 156 to form the header with a new key  $K_H$  which the Information provider maintains in association with the contract CID during the life time of the contract. As mentioned earlier, the key  $K_H$  forms part of the body of the Opener. Finally, the information provider forms the Sealed-COIN by concatenating the header and the body in step 158.

FIG. 9 illustrates in detail the steps in which the information provider generates an Opener. The process starts with an information consumer making an access request with a valid CID and a number of valid access windows AW in step 160. With the CID, the Information provider finds the corresponding key  $K_H$ , which it used in step 156 to encrypt the header fields 119 of the Sealed-COIN, and encrypts  $K_H$  using the information provider's secret key PSK in step 162. The Information provider then forms the Opener by using the CID for field 131, AWEs for field 142 and the above encrypted  $K_H$  for field 144 in step 164. Finally, the Opener is generated by encrypting the above outcome with the access device's public key DPK in step 166.

## 3. Access to Sealed-COIN

As mentioned briefly above, FIGS 11A and 11B describes the controller's logical steps in determining whether to grant the information consumer its access request. Step 200 checks whether the input is uncontrolled information. An example of uncontrolled information is catalog information for the user to browse. If it is uncontrolled information, it is outputted to the output unit 50 over the clear channel 47. Otherwise, the Controller 48 asks the information consumer for an Opener in step 204. The controller uses its own (i.e., the Access Device's) secret key DSK to decrypt the Opener to extract CID and AWEs from field 131 and field 142 in step 206. From the CID, the controller extracts the LAD from field 127. The controller checks whether the LAD matches with its own (i.e., the Access Device's) identification, and verifies whether the current time according to Clock 55 is within one of the AWEs found in field 142. If any of these checks fails, access to controlled information is denied in step 210.

If the checks in step 208 are successful, the con-

troller extracts the PID from field 121, and thus the information provider's public key PPK in step 212. With this key, the controller decrypts the body 145 of the Opener to obtain  $K_H$  in step 214. Using  $K_H$ , the controller then, in step 216, decrypts the header 119 of the Sealed-COIN presented earlier by the information consumer. Then it extracts the value of TAL from field 125 of the header in step 218. The controller then checks in step 220 whether T (denoting the value of  $TAL - LAL + 1$ ) is within the range of  $[1, TAL]$ . In step 222, the access is denied if T is not within the range. When T is within the range, the controller then checks whether T-th access has been made in step 224 in FIG. 11B. It is important to note that the T-th access is recorded in the memory storage 52 in step 231. The second and subsequent attempts for the T-th access will be denied in step 222. If the T-th access has not been made, the controller then decrypts the body 130 of the Sealed-COIN using Key  $K_T$  found in the header field 124. The controller sends the outcome to the Output Unit 50 via clear channel 47 in step 226. In the case where LAL is greater than 1, the controller proceeds to step 230. Here, the controller re-encrypts the COIN using key  $K_{T+1}$  found in field 124 of header 119. Next, the controller decrements the value in field 122 of the header 119 by one and encrypts the new header using key  $K_H$ . The header 119 thus becomes modified header 119'. The modified header 119' and COIN are concatenated to form a new Sealed-COIN which is directed to Information Output Channel 29 for the information to save. Finally, in step 231 the current value of LAL is recorded in the storage 52 for the check in step 224 whether the T-th access has been made. The process terminates in step 232.

While the present invention has been described particularly with reference to FIGS. 1 to 11B with emphasis on a method for controlling the dissemination of digital information in either an off-line or an on-line environment, it should be understood that the figures are for illustration only and should not be taken as limitations on the invention. In addition, it is clear that the methods of the present invention have utility in many applications where control of dissemination of digital information is required.

## Claims

1. In a system for controlling the dissemination of information by an information provider in an off-line manner including at least a storage medium and an access device at an information consumer's disposal, said information including both controlled information, or COIN, and uncontrolled information, a method for providing enhanced control over the usage of controlled information comprising the steps of:

a) encrypting said COIN and a header to pro-



duce a Sealed-COIN on said storage medium, said header comprising at least a total number of legal accesses, number of legal accesses left, a plurality of encryption/decryption keys, and a medium signature for checking and validating the authenticity of said storage medium; 5  
 b) decrypting said header of said Sealed-COIN and checking the values in said header with a controller disposed in said access device upon access of said storage medium by an information consumer; said controller disallowing access to information if any of the checks fails; 10  
 c) decrypting said COIN using one of said encryption/decryption keys and presenting said COIN information to an output unit disposed in said access device if all the checks in b) made by said controller succeed, said header being modified to become modified header such that said number of accesses left is decremented; and 15  
 d) re-encrypting said COIN and said modified header using another of said encryption/decryption keys after each access request by said information consumer until there is no legal access left, 20

whereby said information provider exercises control of access by setting values for said header in accordance to the agreement between the information provider and the information consumer, and the information consumer transparently accesses controlled and uncontrolled information. 25

2. The method as defined in claim 1, characterised in that said header further comprises a plurality of access windows, the value of each said access window being checked by said controller to permit access to said information during a predetermined period of time. 30

3. The method as defined in claim 1 or claim 2 characterised in that said medium signature permits access to said information on said access device only if said controller matches the medium signature of said storage medium with the medium signature read by said access device. 35

4. In a system for controlling the dissemination of information by an information provider in an on-line manner over at least one transmission channel and at least one access device at an information consumer's disposal, said information including both controlled information, or COIN, and uncontrolled information, a method for providing enhanced control over the usage of controlled information comprising the steps of: 40

a) encrypting said COIN and a header to pro-

duce a Sealed-COIN before sending said Sealed-COIN to said information consumer, said header comprising at least a total number of legal accesses, number of legal accesses left, a plurality of encryption/decryption keys for encrypting said information, said header being encrypted by an encryption/decryption key  $K_H$  maintained for the life of a predetermined distribution contract;

b) encrypting a Seal Opener upon receiving access request from an information consumer and sending said Seal Opener to the information consumer, said Seal Opener comprising at least a plurality of access windows and said key  $K_H$ ;

c) decrypting said Seal Opener with a controller disposed in said access device, said controller checking the access windows in said Sealed Opener upon access by the information consumer, said controller disallowing access to said information if any of the checks fails; d) decrypting said header of said Sealed-COIN and checking the values in said header with a controller disposed in said access device upon access of said information by an information consumer, said controller disallowing access to information if any of the checks fails;

e) decrypting said COIN using one of said encryption/decryption keys and presenting said information therein to an output unit disposed in said access device if all the checks in d) made by said controller succeed, said header being modified to become modified header such that said number of accesses left is decremented; and

f) re-encrypting said COIN and said modified header using another of said encryption/decryption keys after each access request by said information consumer until there is no legal access left, 45

whereby said information provider exercises control of access by setting values for said header in accordance to the agreement between the information provider and the information consumer and the information consumer transparently accesses controlled and uncontrolled information.

5. The method as defined in any of claims 1 to 4 characterised in that said information comprises digital information. 50

6. The method as defined in any of claims 1 to 5 characterised in that said controller permits a predetermined number of accesses to said information upon checking the value of said total number of legal accesses left. 55

7. The method as defined in any of claims 1 to 6 characterised in that said header further comprises legal access device identification information, the value of said legal access identification being checked by said controller to permit access only on said legal access device. 5
8. The method as defined in any of claims 4 or 5-7, as dependent on claim 4, characterised in that the access windows of said Seal Opener are checked by said controller to permit access to said information during a predetermined period of time only. 10
9. The method as defined in any of claims 1 to 8 characterised in that said controller is coupled to said output unit over tamper-proof links. 15

#### Patentansprüche

1. Verfahren zur Schaffung einer verbesserten Kontrolle über den Gebrauch kontrollierter Information in einem System zur Steuerung der Verbreitung von Information durch einen Informationslieferanten im Offline-Betrieb, unter Einschluß von zumindest einem Speichermedium und einer Zugriffseinrichtung, die einem Informationsverbraucher zur Verfügung steht, wobei die Information sowohl kontrollierte Information oder COIN als auch unkontrollierte Information einschließt, mit den folgenden Schritten: 25

a) Verschlüsseln der COIN und eines Anfangsblockes zur Erzeugung einer gesiegelten COIN auf dem Speichermedium, wobei der Anfangsblock zumindest eine Gesamtzahl von rechtmäßigen Zugriffen, eine Anzahl von verbleibenden rechtmäßigen Zugriffen, eine Vielzahl von Verschlüsselungs-/Entschlüsselungsschlüsseln und eine Medium-Signatur zur Prüfung und Validierung der Authentizität des Speichermediums umfaßt,

b) Entschlüsselung des Anfangsblockes der gesiegelten COIN Prüfen der Werte in dem Anfangsblock mit einem Steuergerät, das in der Zugriffseinrichtung angeordnet ist, beim Zugriff auf das Speichermedium durch einen Informationsverbraucher, wobei das Steuergerät den Zugriff auf die Information verweigert, wenn irgendeine der Prüfungen fehlschlägt,

c) Entschlüsseln der COIN unter Verwendung eines der Verschlüsselungs-/Entschlüsselungsschlüssel und Zuführung der COIN-Information zu einer Ausgabeeinheit, die in der Zugriffseinrichtung angeordnet ist, wenn alle von dem Steuergerät in b) durchgeführten Prüfungen erfolgreich sind, wobei der Anfangsblock modifiziert wird, um zu einem modifizier-

ten Anfangsblock derart zu werden, daß die Anzahl der verbleibenden Zugriffe abwärts gezählt wird, und

d) Neuverschlüsseln der COIN und des modifizierten Anfangsblockes unter Verwendung eines anderen der Verschlüsselungs-/Entschlüsselungsschlüssel nach jeder Zugriffsanforderung von dem Informationsverbraucher, bis kein rechtmäßiger Zugriff verbleiben ist,

wodurch der Informationslieferant eine Kontrolle des Zugriffs durch Festsetzen von Werten für den Anfangsblock entsprechend der Vereinbarung zwischen dem Informationslieferanten und dem Informationsverbraucher ausübt und der Informationsverbraucher in transparenter Weise einen Zugriff auf kontrollierte und unkontrollierte Information ausführt.

2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß der Anfangsblock weiterhin eine Vielzahl von Zugriffsfenstern umfaßt, wobei der Wert jedes dieser Zugriffsfenster von dem Steuergerät geprüft wird, um den Zugriff auf die Information während einer vorgegebenen Zeitperiode zuzulassen. 30

3. Verfahren nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß die Medium-Signatur den Zugriff auf die Information auf der Zugriffseinrichtung lediglich dann ermöglicht, wenn das Steuergerät eine Übereinstimmung der Medium-Signatur des Speichermediums mit der Medium-Signatur ergibt, die von der Zugriffseinrichtung gelesen wird.

4. Verfahren zur Schaffung einer verbesserten Kontrolle über den Gebrauch kontrollierter Information in einem System zur Steuerung der Verbreitung von Information durch einen Informationslieferanten in einer Online-Weise über zumindest einen Übertragungskanal und zumindest eine Zugriffseinrichtung, die einem Informationsverbraucher zur Verfügung steht, wobei die Information sowohl kontrollierte Information oder COIN als auch unkontrollierte Information einschließt, mit den folgenden Schritten: 35

a) Verschlüsselung der COIN und eines Anfangsblockes zur Erzeugung einer gesiegelten COIN, bevor die gesiegelte COIN an den Informationsverbraucher gesandt wird, wobei der Anfangsblock zumindest eine Gesamtzahl von rechtmäßigen Zugriffen, eine Anzahl von verbleibenden rechtmäßigen Zugriffen, eine Vielzahl von Verschlüsselungs-/Entschlüsselungsschlüsseln zur Verschlüsselung der Information umfaßt, wobei der Anfangsblock mit einem Verschlüsselungs-/Entschlüsselungsschlüssel  $K_H$  verschlüsselt ist, der für die Lauf-

- zeit eines vorgegebenen Verteilungsvertrages aufrechterhalten wird,
- b) Verschlüsseln einer Versiegelungsfreigabe bei Empfang einer Zugriffsanforderung von einem Informationsverbraucher und Senden der Versiegelungsfreigabe an den Informationsverbraucher, wobei die Versiegelungsfreigabe zumindest eine Vielzahl von Zugriffsfenstern und den Schlüssel  $K_H$  umfaßt,
- c) Entschlüsseln der Versiegelungsfreigabe mit einem in der Zugriffseinrichtung angeordneten Steuergerät, wobei das Steuergerät das Zugriffsfenster in der Versiegelungsfreigabe bei Zugriff durch den Informationsverbraucher prüft und das Steuergerät einen Zugriff auf die Information verweigert, wenn eine der Prüfungen fehlschlägt,
- d) Entschlüsseln des Anfangsblockes der gesiegelten COIN und Prüfen der Werte in dem Anfangsblock mit einem in der Zugriffseinrichtung angeordneten Steuergerät bei Zugriff auf die Information durch einen Informationsverbraucher, wobei das Steuergerät den Zugriff auf die Information verweigert, wenn eine der Prüfungen fehlschlägt,
- e) Entschlüsseln der COIN unter Verwendung eines der Verschlüsselungs-/Entschlüsselungs-Schlüssel und Lieferung der darin enthaltenen Information an eine Ausgabeeinheit, die in der Zugriffseinrichtung angeordnet ist, wenn alle die von dem Steuergerät in d) gemachten Prüfungen erfolgreich sind, wobei der Anfangsblock modifiziert wird, um zu einem modifizierten Anfangsblock derart zu werden, daß die Anzahl der verbleibenden Zugriffe abwärts gezählt wird,
- f) erneutes Verschlüsseln der COIN und des modifizierten Anfangsblockes unter Verwendung eines anderen der Verschlüsselungs-/Entschlüsselungs-Schlüssel nach jeder Zugriffsanforderung von dem Informationsverbraucher, bis kein rechtmäßiger Zugriff verbleiben ist,
- wodurch der Informationslieferant eine Kontrolle des Zugriffs dadurch ausübt, daß Werte für den Anfangsblock entsprechend der Vereinbarung zwischen dem Informationslieferanten und dem Informationsverbraucher gesetzt werden und der Informationsverbraucher in transparenter Weise einen Zugriff auf kontrollierte und unkontrollierte Information ausführt.
5. Verfahren nach einem der Ansprüche 1 bis 4, dadurch gekennzeichnet, daß die Information digitale Information umfaßt.
6. Verfahren nach einem der Ansprüche 1 bis 5, dadurch gekennzeichnet, daß das Steuergerät eine

vorgegebene Anzahl von Zugriffen auf die Information nach der Prüfung des Wertes der Gesamtzahl der verbleibenden rechtmäßigen Zugriffe ermöglicht.

7. Verfahren nach einem der Ansprüche 1 bis 6, dadurch gekennzeichnet, daß der Anfangsblock weiterhin Identifikationsinformation für eine rechtmäßige Zugriffseinrichtung umfaßt, wobei der Wert der rechtmäßigen Zugriffsinformation von dem Steuergerät geprüft wird, um einen Zugriff lediglich auf die rechtmäßige Zugriffseinrichtung zu ermöglichen.
8. Verfahren nach einem der Ansprüche 4 oder 5 bis 7 unter Rückbeziehung auf Anspruch 4, dadurch gekennzeichnet, daß die Zugriffsfenster der Versiegelungsfreigabe durch das Steuergerät geprüft werden, um den Zugriff auf die Information nur während einer vorgegebenen Zeitperiode zuzulassen.
9. Verfahren nach einem der Ansprüche 1 bis 8, dadurch gekennzeichnet, daß das Steuergerät mit der Ausgabeeinheit über manipulationssichere Verbindungen gekoppelt ist.

#### Revendications

1. Dans un système pour contrôler la propagation d'informations via un fournisseur d'informations d'une manière en différé, englobant au moins un support de mémoire et un dispositif d'accès à la disposition de l'utilisateur des informations, lesdites informations englobant à la fois des informations contrôlées ou de type COIN et des informations non contrôlées, un procédé pour améliorer le contrôle de l'utilisation des informations contrôlées, comprenant les étapes consistant à:

a) chiffrer lesdites informations de type COIN et une en-tête pour obtenir des informations protégées de type COIN sur ledit support de mémoire, ladite en-tête comprenant au moins un nombre total d'accès légaux, le nombre d'accès légaux restants, plusieurs clés de chiffrement/déchiffrement, et une signature de support pour vérifier et valider l'authenticité dudit support de mémoire;

b) déchiffrer ladite en-tête desdites informations protégées de type COIN et vérifier les valeurs dans ladite en-tête avec un contrôleur disposé dans ledit dispositif d'accès lors de l'accès audit support de mémoire par un utilisateur des informations; ledit contrôleur refusant l'accès aux informations dans le cas où l'une quelconque des vérifications échoue;

c) déchiffrer lesdites informations de type COIN en utilisant une desdites clés de chiffrement/

- déchiffrement et présenter lesdites informations de type COIN à une unité de sortie disposée dans ledit dispositif d'accès lorsque toutes les vérifications dans b) mises en oeuvre par ledit contrôleur sont couronnées de succès, ladite en-tête étant modifiée pour devenir une en-tête modifiée dans le sens où ledit nombre d'accès restants est décrémenté; et
- d) rechiffrer lesdites informations de type COIN et ladite en-tête modifiée en utilisant une autre clé de chiffrement/déchiffrement après chaque demande d'accès émanant dudit utilisateur d'informations jusqu'à épuisement des accès légaux, par lequel ledit fournisseur d'informations exerce un contrôle de l'accès en attribuant des valeurs à ladite en-tête en fonction d'une concertation entre le fournisseur d'informations et l'utilisateur des informations, l'utilisateur des informations accédant de manière transparente aux informations contrôlées et non contrôlées.
2. Procédé selon la revendication 1, caractérisé en ce que ladite en-tête comprend en outre plusieurs fenêtres d'accès, la valeur de chacune desdites fenêtres d'accès étant vérifiée par ledit contrôleur pour permettre l'accès auxdites informations pendant un laps de temps prédéterminé.
3. Procédé tel que défini à la revendication 1 ou 2, caractérisé en ce que ladite signature de support permet d'accéder auxdites informations sur ledit dispositif d'accès uniquement lorsque ledit contrôleur établit une correspondance entre la signature de support dudit support de mémoire et la signature de support lue par ledit dispositif d'accès.
4. Dans système pour contrôler la propagation d'informations via un fournisseur conformations d'une manière en ligne sur au moins un canal de transmission et au moins un dispositif d'accès à la disposition d'un utilisateur des informations, lesdites informations englobant à la fois des informations contrôlées ou de type COIN et des informations non contrôlées, un procédé pour améliorer le contrôle de l'utilisation des informations contrôlées, comprenant les étapes consistant à:
- a) chiffrer lesdites informations de type COIN et une en-tête pour obtenir des informations protégées de type COIN avant d'envoyer lesdites informations protégées de type COIN audit utilisateur des informations, ladite en-tête comprenant au moins un nombre total d'accès légaux, un nombre d'accès légaux restants, plusieurs clés de chiffrement/déchiffrement pour chiffrer lesdites informations, ladite en-tête étant chiffrée via une clé  $K_H$  de chiffrement/déchiffrement maintenue pendant la durée d'un contrat de distribution prédéterminé;
- b) chiffrer un décodeur lors de la réception d'une demande d'accès de la part d'un utilisateur des informations et envoyer ledit décodeur à l'utilisateur des informations, ledit décodeur comprenant au moins plusieurs fenêtres d'accès et ladite clé  $K_H$ ;
- c) déchiffrer ledit décodeur avec un contrôleur disposé dans le dispositif d'accès, ledit contrôleur vérifiant les fenêtres d'accès dans ledit décodeur lors de l'accès via l'utilisateur d'informations, ledit contrôleur refusant l'accès auxdites informations dans le cas où l'une quelconque des vérifications échoue;
- d) déchiffrer ladite en-tête desdites informations protégées de type COIN et vérifier les valeurs dans ladite en-tête avec un contrôleur disposé dans ledit dispositif d'accès lors de l'accès auxdites informations par un utilisateur des informations; ledit contrôleur refusant l'accès aux informations dans le cas où l'une quelconque des vérifications échoue;
- e) déchiffrer lesdites informations de type COIN en utilisant une desdites clés de chiffrement/déchiffrement et présenter lesdites informations de type COIN à une unité de sortie disposée dans ledit dispositif d'accès lorsque toutes les vérifications dans d) mises en oeuvre par ledit contrôleur sont couronnées de succès, ladite en-tête étant modifiée pour devenir une en-tête modifiée dans le sens où ledit nombre d'accès restants est décrémenté; et
- f) rechiffrer lesdites informations de type COIN et ladite en-tête modifiée en utilisant une autre clé de chiffrement/déchiffrement après chaque demande d'accès émanant dudit utilisateur d'informations jusqu'à épuisement des accès légaux,
- par lequel ledit fournisseur d'informations exerce un contrôle de l'accès en attribuant des valeurs à ladite en-tête en fonction d'une concertation entre le fournisseur d'informations et l'utilisateur des informations, l'utilisateur des informations accédant de manière transparente aux informations contrôlées et non contrôlées.
5. Procédé tel que défini dans l'une quelconque des revendications 1 à 4, caractérisé en ce que lesdites informations comprennent des informations numériques.
6. Procédé selon l'une quelconque des revendications 1 à 5, caractérisé en ce que ledit contrôleur permet un nombre prédéterminé d'accès auxdites informations après vérification de la valeur dudit nombre total d'accès légaux restants.

7. Procédé selon l'une quelconque des revendications 1 à 6, caractérisé en ce que ladite en-tête comprend en outre des informations d'identification du dispositif d'accès légal, la valeur desdites identifications de l'accès légal étant vérifiées par ledit contrôleur pour permettre l'accès uniquement audit dispositif d'accès légal. 5
8. Procédé selon l'une quelconque des revendications 4 ou 5-7 lorsqu'elles dépendent de la revendication 4, caractérisé en ce que les fenêtres d'accès dudit décodeur sont vérifiées par ledit contrôleur pour permettre l'accès auxdites informations uniquement au cours d'un laps de temps prédéterminé. 10 15
9. Procédé tel que défini dans l'une quelconque des revendications 1 à 8, caractérisé en ce que ledit contrôleur est couplé à ladite unité de sortie via des liaisons inviolables. 20

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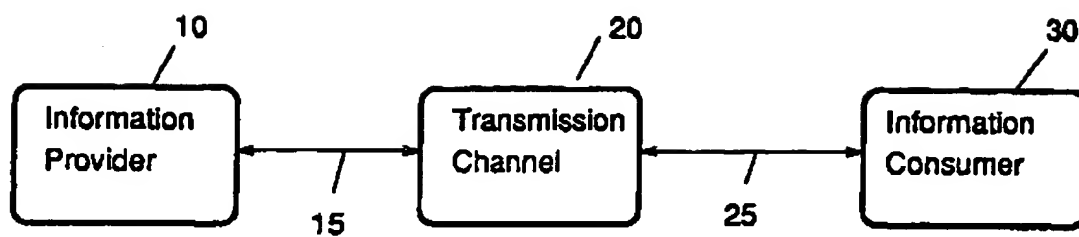


Figure 1

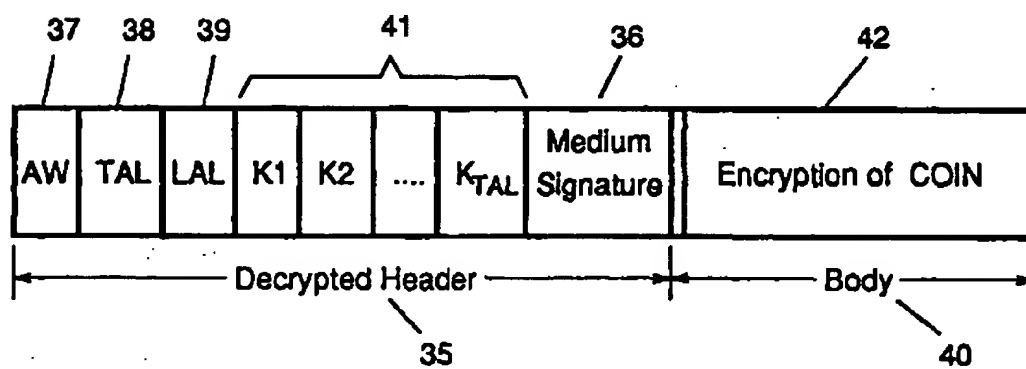


Figure 2

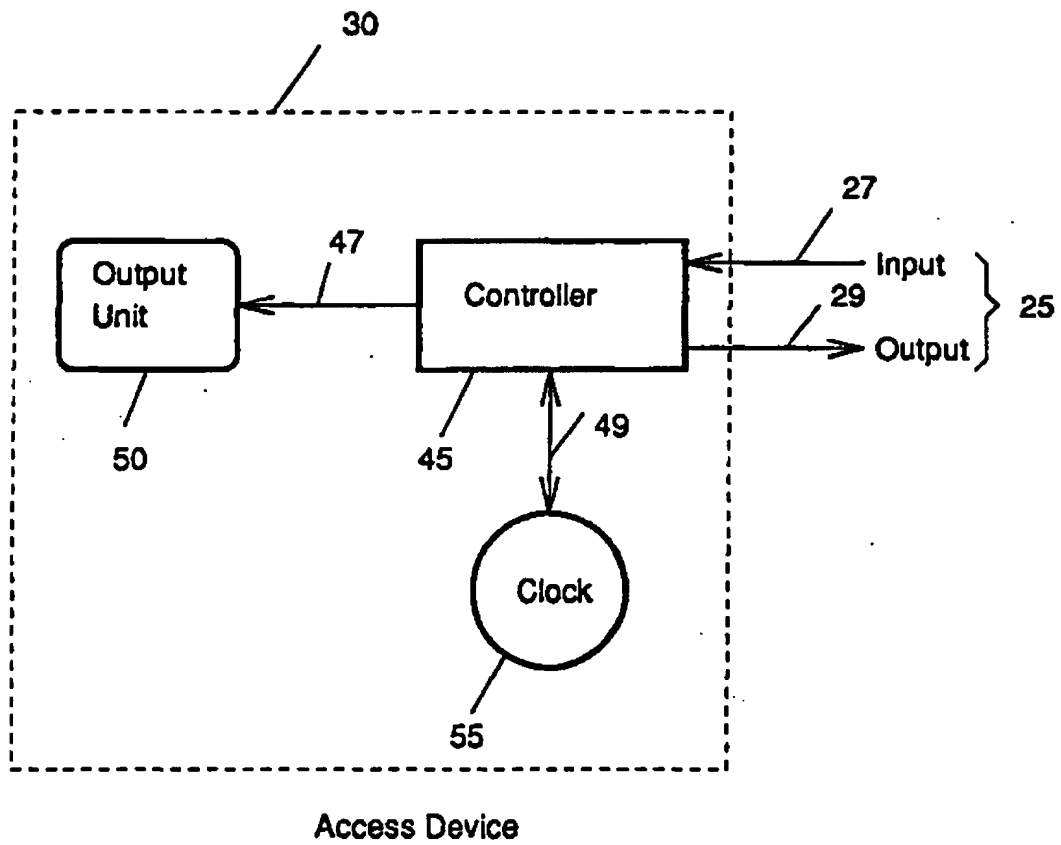


Figure 3

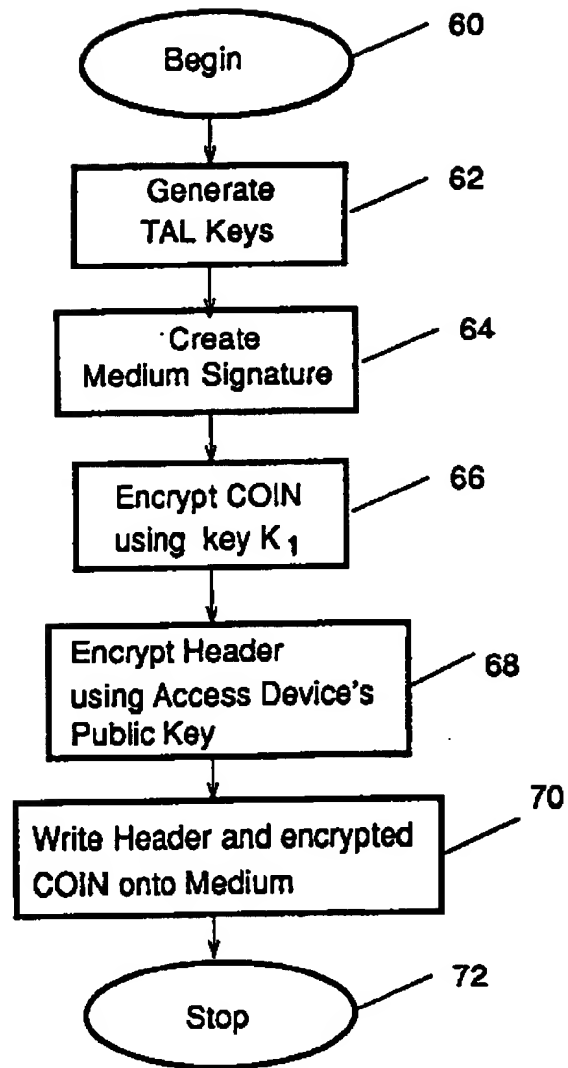


Figure 4



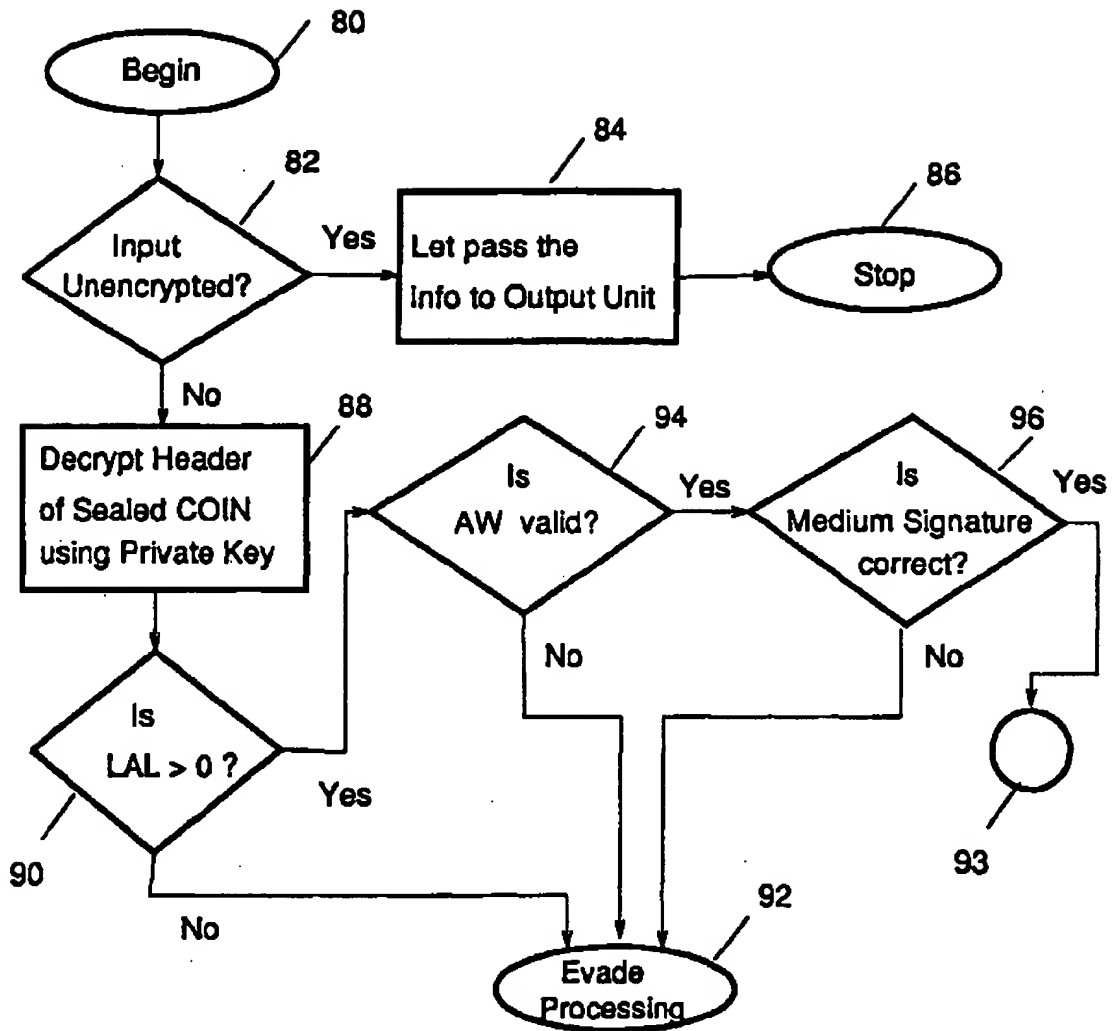


Figure 5A

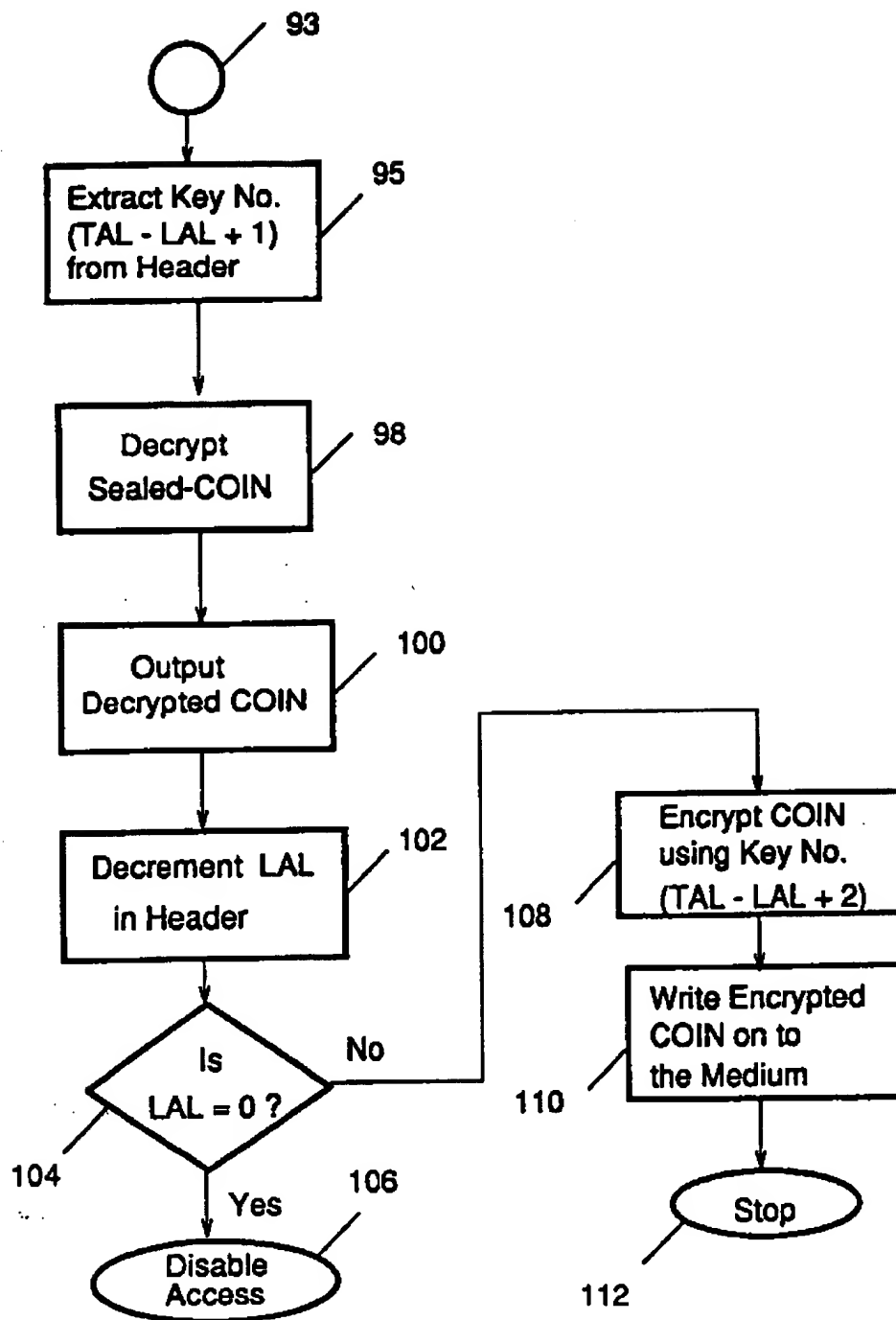


Figure 5B

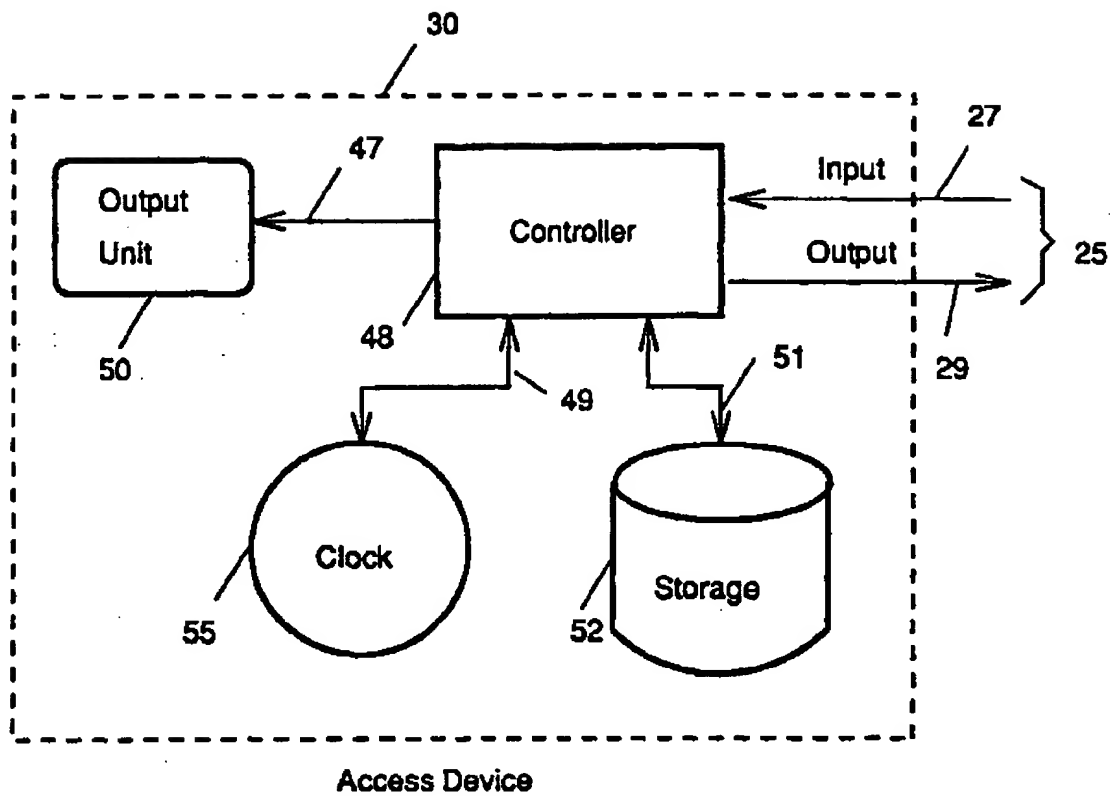


Figure 6

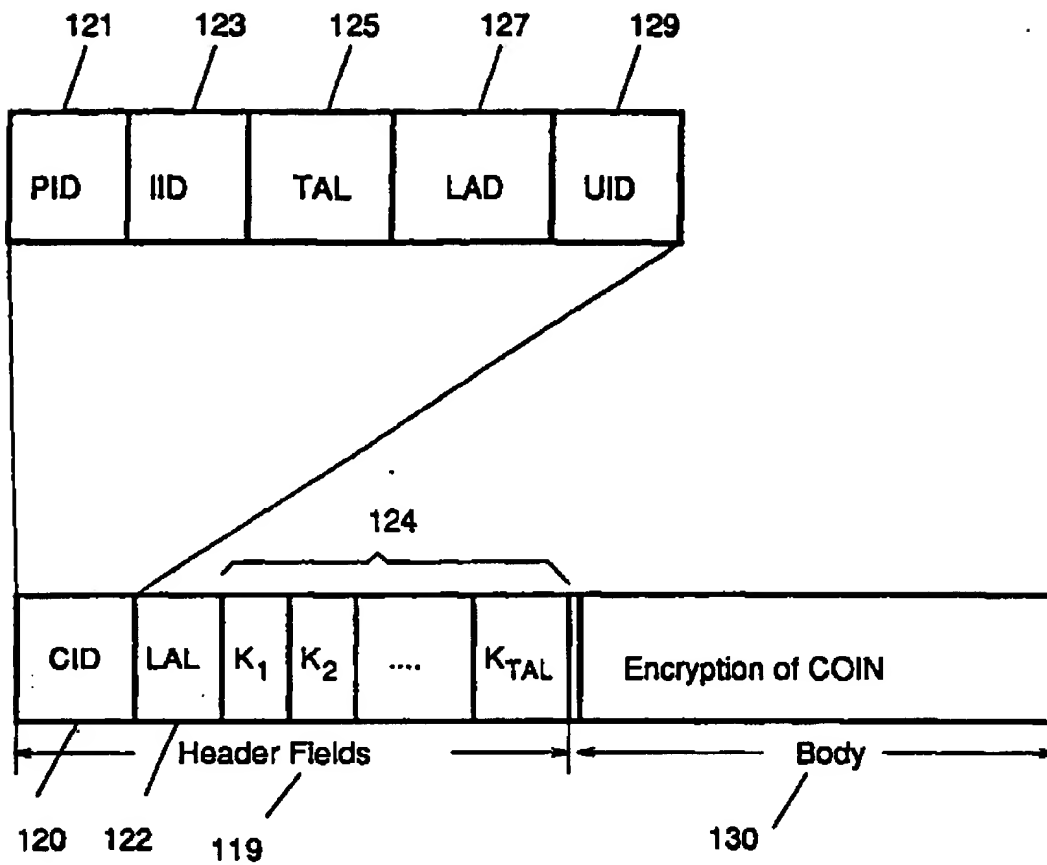


Figure 7A

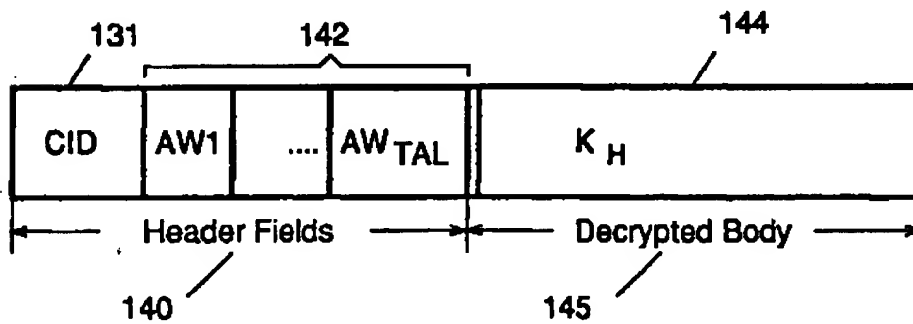


Figure 7B

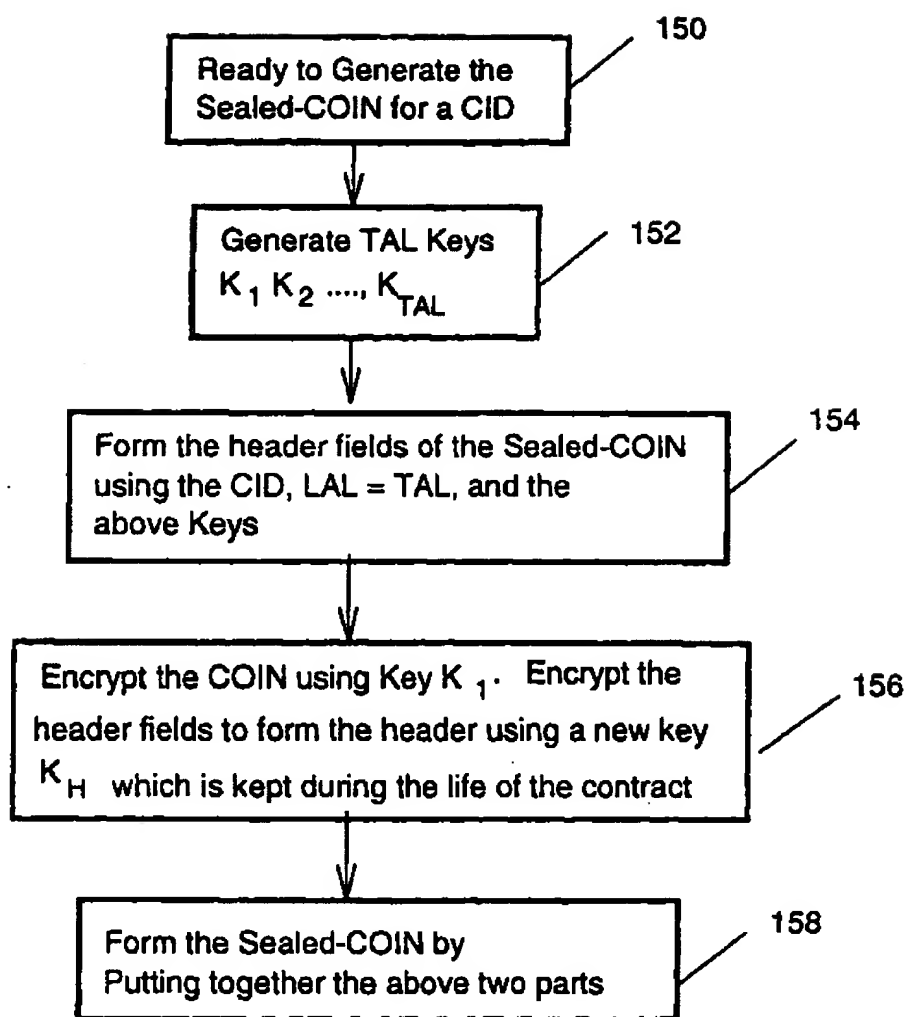


Figure 8

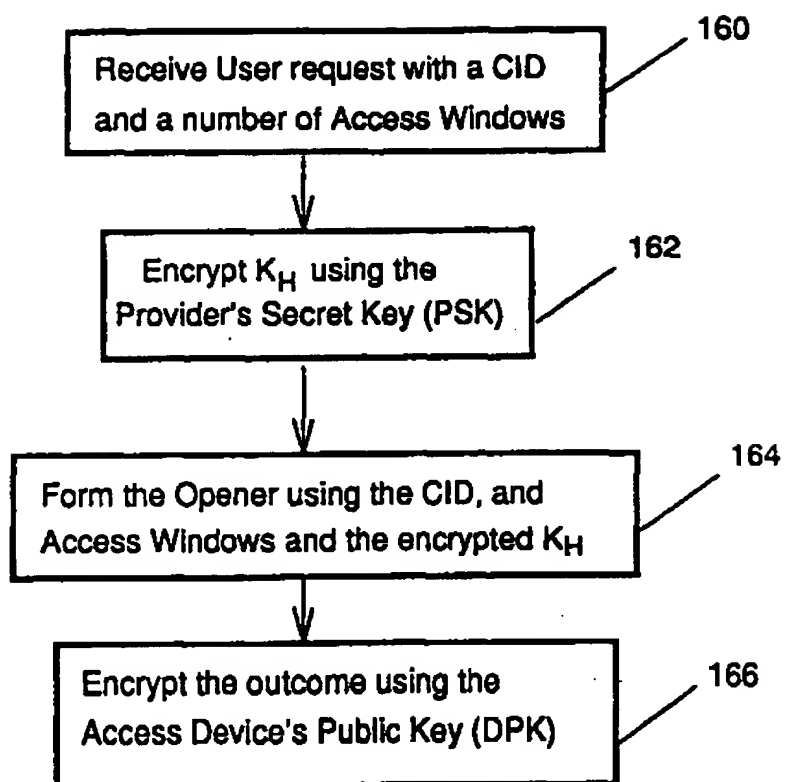


Figure 9

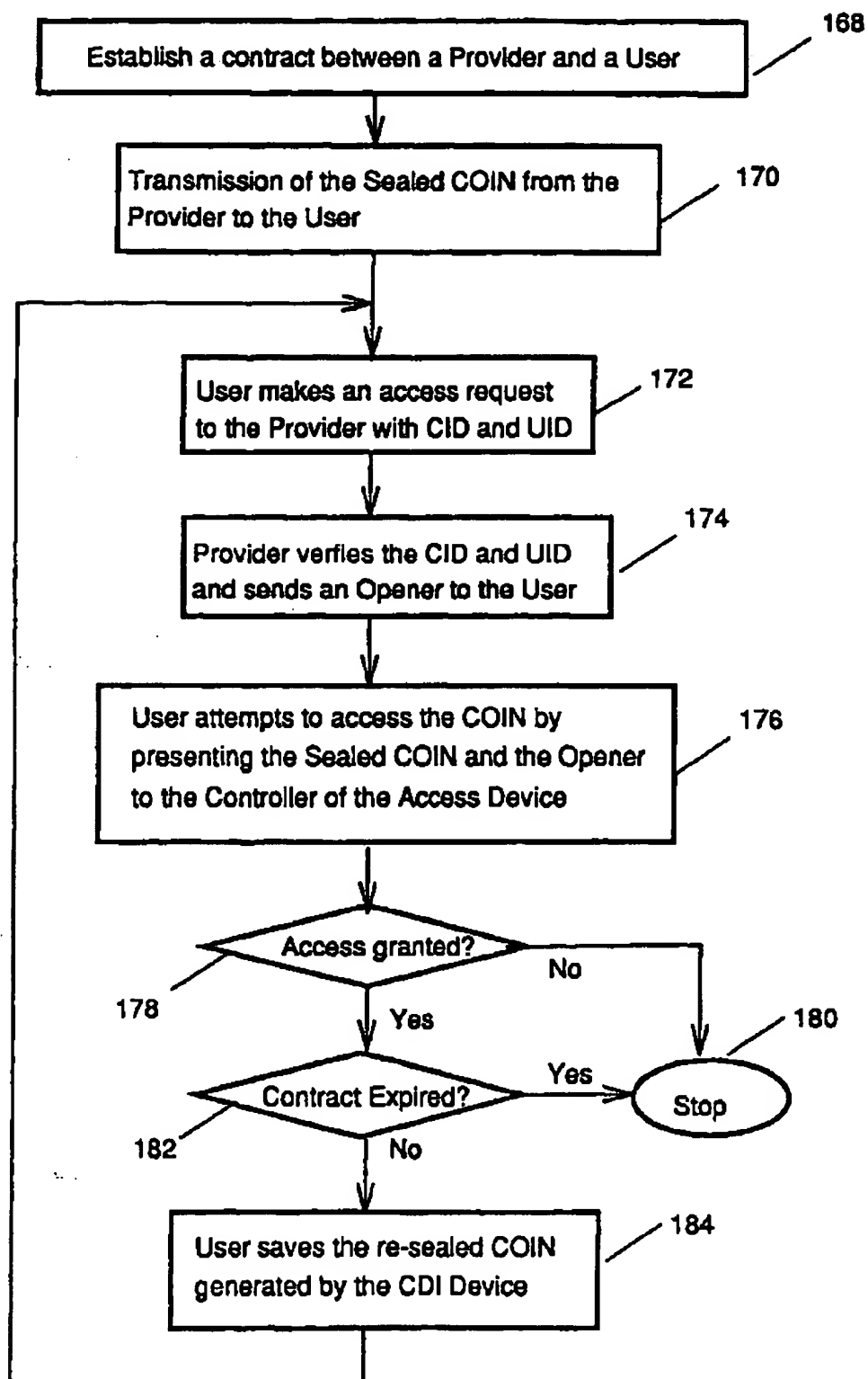


Figure 10

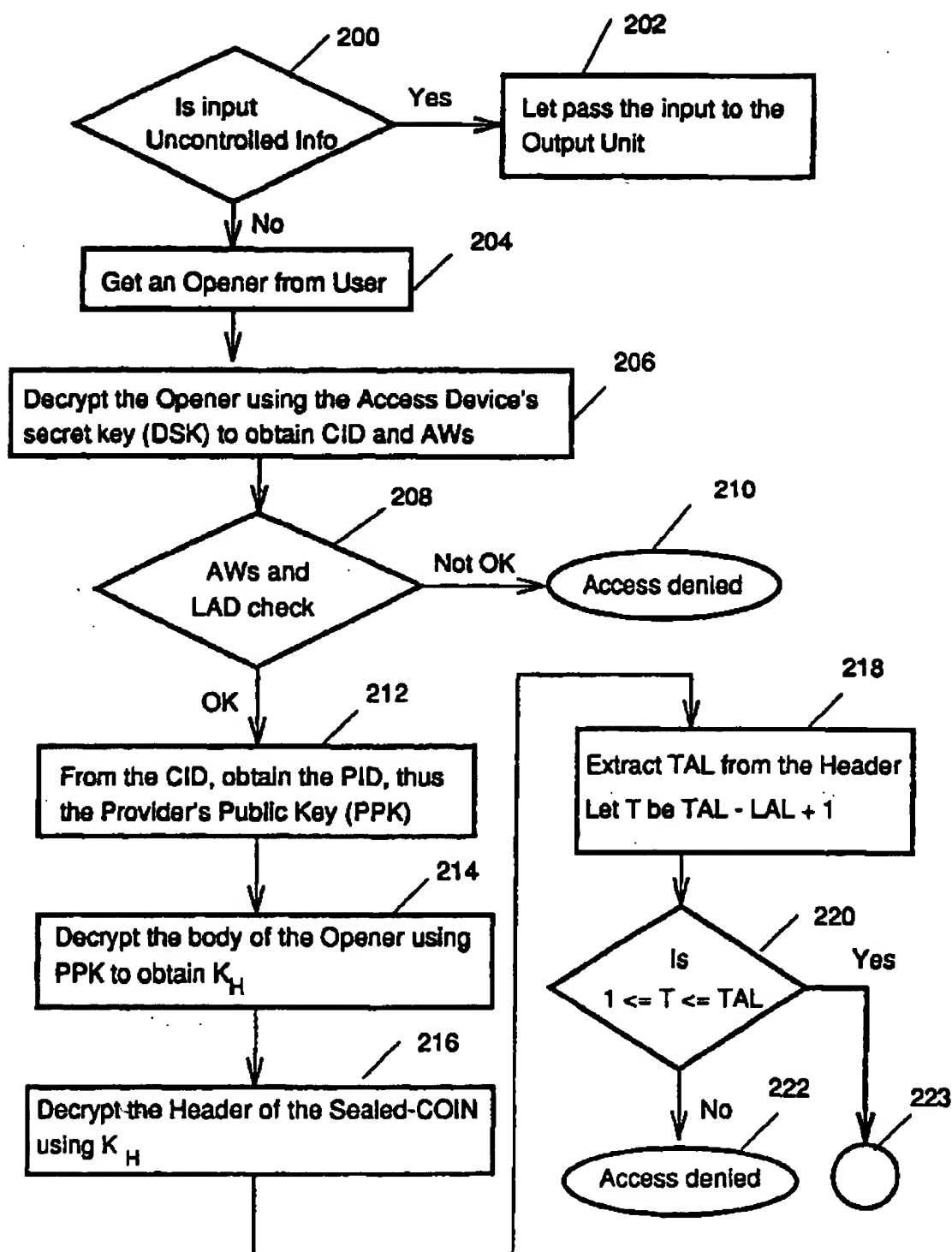


Figure 11A



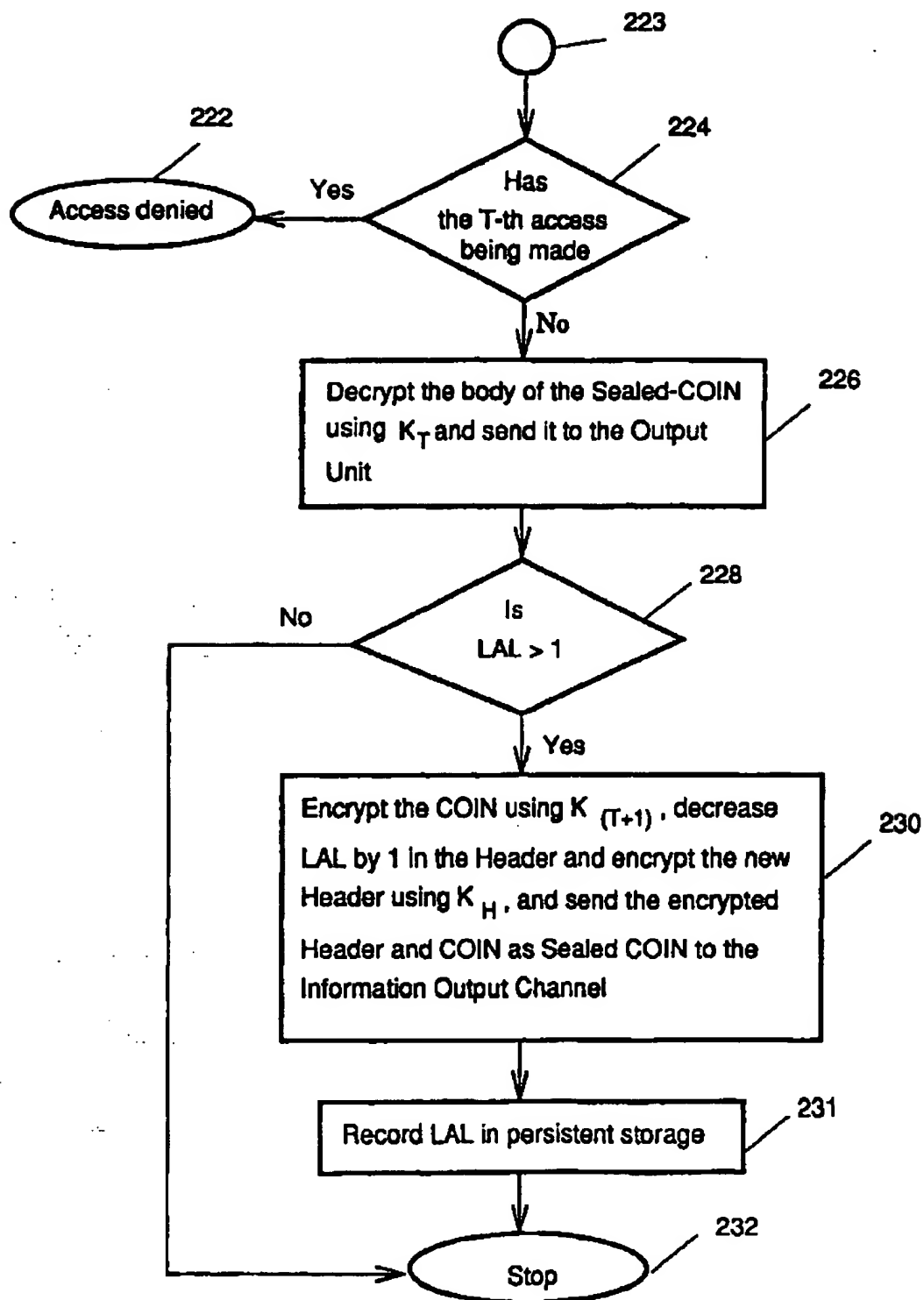


Figure 11B

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